The International
Journal of
Integrated
Engineering

Evaluation of End-of-Life Vehicle Recycling in India: A Techno-Socio-Economic Analysis

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Abstract: In light of the rapidly advancing Indian automotive sector, the issue of end-of-life vehicles (ELVs) has emerged as a matter of significant concern. Particularly critical aspects encompass recycling procedures, environmental impacts, and social implications. With the inevitable proliferation of ELVs anticipated in the next decade, the imperative for effective and sustainable ELV management becomes paramount, necessitating a comprehensive analysis of India's burgeoning ELV recycling landscape. The present study endeavors to scrutinize India's ELV recycling system from technological, social, and economic perspectives, constituting a preliminary step toward a judicious evaluation of sustainability in ELV recycling and performing a SWOT (strengths, weaknesses, opportunities, and threats) analysis to appraise India's ELV recycling framework comprehensively. Furthermore, the ensuing recommendations shall furnish invaluable insights for the development and implementation of forthcoming regulatory and legal frameworks that adequately incorporate the economic, social, environmental, and technological aspects of ELV recycling in India. To accomplish this endeavor, the study has diligently conducted in-depth interviews with pertinent stakeholders, undertaken rigorous field investigations, and administered comprehensive surveys. Additionally, an exhaustive examination of the existing literature has been undertaken to probe the current ELV recycling system, address lingering challenges, and proffer recommendations to elevate the ELV recycling infrastructure. The outcomes of this study may assist in developing deeper comprehension of India's ELV recycling system while furnishing pragmatic recommendations to fortify its efficacy.

Keywords: End-of-Life Vehicle (ELV), sustainability, recycling, SWOT analysis

1. Introduction

The growing demand for vehicles has led to a steady rise in global automobile production; India is not immune to this phenomenal expansion and has been witnessing one of the fastest motorization rates globally [1,2]. The upsurge of vehicles on the roads eventually will become a delude of end-of-life of vehicles (ELVs). ELVs include all kinds of vehicles that are no longer in use owing to no roadworthiness for their age and become a critical waste in society [3]. ELV management has taken new prominence in concerns about the environment, material efficiency, and social aspects of the circular economy [4]. On the one hand, it contains a plethora of rare materials and a host of recyclable parts and components; on the other hand, it incorporates a myriad of potential pollutants [5]. ELV recycling has attracted the

authority's attention as it offers significant material extraction and recovery, along with the appropriate disposal of contaminants [6–8].

The need for materials in the automotive industry has significantly increased along with the demand for automobiles [9,10]. Countries like India have been experiencing a material crisis as the natural resources on that planet are dwindling at an exponential pace [11]. Through appropriate recycling of ELVs, a host of disparate materials can be recovered in a significant quantity that can mitigate the material crisis in the world and ameliorate the material supply to the automotive as well as other industries [12,13]. Inappropriately disposed of ELVs aggravates environmental pollution and endangers our society as ELVs that contain pollutants discharge them into the environment directly [14]. The proper ELV recycling system disposes of ELVs in environmentally sound ways and prevents contaminants from releasing into the atmosphere [15]. The proper ELV recycling system yields an essential opportunity to create a close loop of materials flow that has the potential to cherish and nurture the circular economy for long-term viability in the automotive sector [16,17]. Countries like Japan, the USA, European Union (EU), and China have well-established and excellent ELV recycling systems that allow them to have significantly higher material extraction rates and sustainably dispose of potential pollutants as a preventive approach to combat environmental pollution [18–21].

India's nascent ELV recycling system grapples with an array of challenges [22]. Predominantly, the country's ELV recycling landscape is predominantly comprised of informal and semi-formal facilities, with only a handful of formal ELV recycling centers in existence [23]. Driven solely by economic interests, the informal sector operates without adhering to standardized guidelines, leading to a lack of transparency in its operations and procedures, which represents a significant hindrance to the sustainable growth of India's ELV sector, notwithstanding its substantial contributions to national welfare. Compounding the predicament is the employment of subpar technology and the glaring absence of proper infrastructure, resulting in suboptimal material extraction and recovery rates [23]. Without a legislative and regulatory policy, many car owners still discard their abandoned vehicles in the dumping yard or along the roads due to their low economic value, which increases landfills [24].

It is evident from contemporary literature that little emphasis is given to India's ELV recycling system. Research focusing on India's ELV recycling system from a triple bottom lines perspective is imperative for sustainably developing and enhancing the ELV recycling sector. Current literature also reveals that a limited number of assessment studies have been carried out to evaluate the current system, address the persistent issues, and highlight the critical factors that thwart sustainability in ELV recycling. As little attention has been poured into India's ELV system by contemporary researchers, the Indian authority has received few constructive, realistic, and profound suggestions for devising a legal and regulatory framework to facilitate material extraction and recovery rates. This study aims to investigate India's ELV recycling system from the technological, social, and economic perspectives as a preliminary step to critically evaluating sustainability in ELV recycling, performing a SWOT analysis to analysis to assess and evaluate the ELV recycling system to identify the strengths and critical factors that need to be enhanced before making any strategic move. Subsequently, recommendations offer insights that will be instrumental in designing and implementing any upcoming regulatory and legal framework that appropriately incorporates the economic, social, and environmental, technological aspects of ELV recycling in India.

2. Methodology

This study adopts a comprehensive and integrated approach, encompassing quantitative, qualitative, and secondary research methodologies, to thoroughly examine India's ELV recycling system from a techno-socio-economic standpoint. The primary aim is to conduct a SWOT analysis and propose insightful recommendations to enhance the existing system. For this investigation, five prominent automobile hubs, namely Kolkata, Chennai, Mumbai, Delhi, and Jamshedpur, have been carefully selected to assess the current status of ELV recycling in India. The research involves detailed interviews with 183 individuals from these chosen automobile hubs, using a well-structured questionnaire. This questionnaire has been meticulously designed, endorsed, and validated by experts and academicians to effectively achieve the study's objectives. Figure 1 illustrates the composition of the interview process.

Fig. 1 - Interview composition

The respondents of the interview include academicians, experts, vehicle owners, key stakeholders involved in the ELV recycling industries, individuals from government authorized agencies, and individuals in general in varying proportions. The responses of the quantitative approach have been analyzed to investigate the ELV recycling system in India from techno-socio-economic perspectives. The qualitative research has been carried out through field investigation and individual in-depth interviews, even though through deploying questionnaires, insightful information and data have been collected, which plays an imperative role in revealing the real-world situation. The essential information and data obtained from qualitative research have been employed for the SWOT analysis to assess and evaluate the ELV recycling system to identify the strengths and critical factors that need to be enhanced before making any strategic move. The secondary research has been carried out to develop the foundation of this research; the comprehensive literature review assists in gaining an understanding of the existing research and making aware of best, international, and standard practices. Based on the knowledge and information gained from quantitative, qualitative, and secondary research, this research has made insightful and pragmatic recommendations that will be instrumental in designing and implementing any upcoming regulatory and legal framework. Figure 2 illustrates the methodological framework for this research.
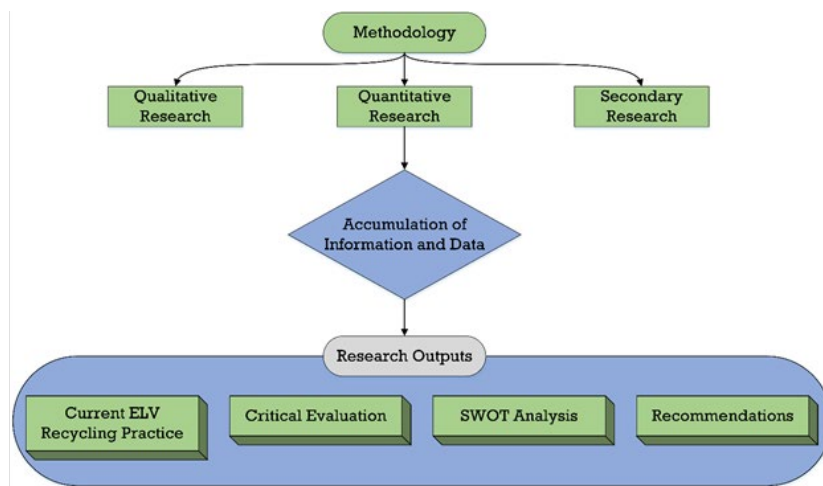

Fig. 2 - Methodological framework of this study

3. Current Practice of ELV Recycling in India

Figure 3 illustrates the intricacies and operations of ELVs in both the formal and informal sectors within the Indian context. The prevalence of informality in India's ELV recycling system is conspicuous, as the practices and procedures within the informal sectors lack adherence to any standardized protocols or guidelines. Conversely, the formal sector, albeit a minority, dutifully adheres to legal guidelines promulgated by the authorities. The impetus behind the informal sector lies primarily in economic gains, with the selective recovery of economically valuable components such as engines, gear systems, chassis, and wheels from ELVs. Subsequently, the residual car hulks are sold to unapproved third parties for subsequent operations, including shredding. Operating with rudimentary technology, the informal sector faces constraints in extracting economically valuable materials from ELVs, thus resulting in suboptimal rates of material recovery and extraction. On the contrary, the formal ELV recycling sector operates with standard guidelines and systematic procedures given by the authorities that begin with a proper deregistration process of ELVs. After deregistration, they remove potential pollutants from the ELVs, like engine oil, brake oil, coolant, etc., and dispose of them in environmentally sound ways. In dismantling operations, they recover recyclable parts from the ELVs for future use. After dismantling, the remaining car hulk is shredded for further material recovery. The shredding process generates automotive shredder residue (ASR) as the final product, which contains many ferrous and non-ferrous metals; hence it has a high economic value. But, due to a lack of technology, the formal sector cannot extract values from ASR and dispose of them at landfills. However, the materials recycling and recovery rates are comparatively high in the formal sector than in the informal sector, but it is not on par with developed countries. ELV recycling in India is at a nascent stage but endeavoring to fledge. Due to the lack of legislative and regulatory policy, there is no compulsion for car owners to hand over their abandoned vehicles to the authorized ELV recycler; hence, an insufficient number of ELVs come to the authorized ELV recycling center. That is a significant barrier to developing a formal ELV recycling center.
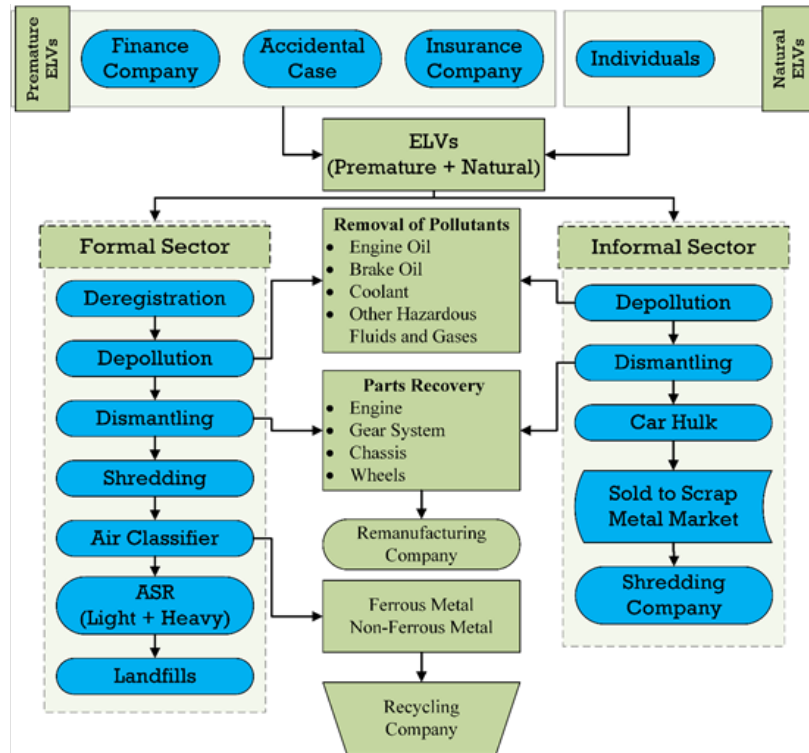
Fig. 3 - The current practice of ELV recycling system in India

4. Critical Findings

The results of this study's objective measurements have been demonstrated and analyzed in this section. This paper arranges the findings from social, economic, and technological perspectives in the below-mentioned sections.

4.1 Social Perspectives

This study has evaluated the social awareness level by objective assessment. Figure 4 reveals the awareness level of the Indian nation about ELV recycling; this study has found that a significantly large fraction of the people (38 %) is still unaware of recycling abandoned vehicles, whereas a significant majority (62 %) of the respondents are well-aware about the significance recycling of the scrap vehicles and the economic values of ELVs. During the interview, many people expressed concern about the lack of social awareness, and they deemed it a potential barrier that thwarts the sustainability of ELV recycling. During the survey, we enumerated the methods of disposing of abandoned vehicles. Table 1 lists the conventional methods of disposing of scrap vehicles. Selling abandoned vehicles to the mechanic and second-hand vehicle buying agencies are the prevalent methods of disposing of vehicles, whereas few people (8 %) prefer to exchange the abandoned vehicle for a new one. The malpractice of throwing abandoned vehicles at the dumping yard is still present among vehicle owners. Significant respondents perceive that a lack of infrastructure and policy prevents the formalization of vehicle disposal methods.
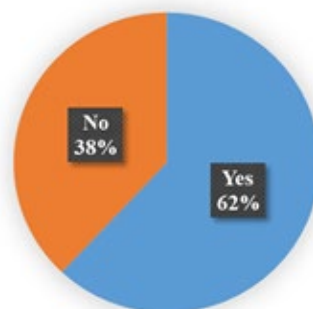

Fig. 4 - Have you heard about ELV recycling?

Table 1 - How do you dispose of vehicles?

	Percentage
Sell to a second-hand vehicle buying agency	30%
Sell to a mechanic	45%
Exchange	8%
Throw at the dumping site	4%
Auctioned	6%
Others	7%

4.2 Economical Perspectives

ELVs contain many economically valuable materials. This study enumerated the list of the most profitable recyclable parts of ELVs. Table 2 lists the most lucrative recyclable parts; a total of 30% of respondents perceive the engine as the most lucrative recyclable part of ELVs, then followed by gear system and differential (25 %), chassis (25 %), body (10 %), and cowl (10 %). Different types of abandoned vehicles come to the ELV recycler and give different economic benefits. Figure 5 unveils that exactly half of the respondents believe that recycling commercial goods vehicles provide the highest amount of profit, followed by commercial passenger vehicle (25 %), private vehicle (10 %), military vehicle (5 %), private vehicle (5 %), three-wheeler (3 %), and other vehicles (2 %). ELV recycling has received great attention from both researchers and industries. This study took notes thoroughly about the expansion of the ELV recycling business in India. Figure 6 shows that a total of 52 % of respondents perceive no change in the industry in the past ten years, and 23 % of respondents believe that the business has shrunk in the last ten years. On the contrary, 15 % of respondents believe that the business has experienced little growth, and 10 % of respondents perceive that the business has made significant expansion.

Table 2 - Which part of vehicle recycling gives the highest profit?

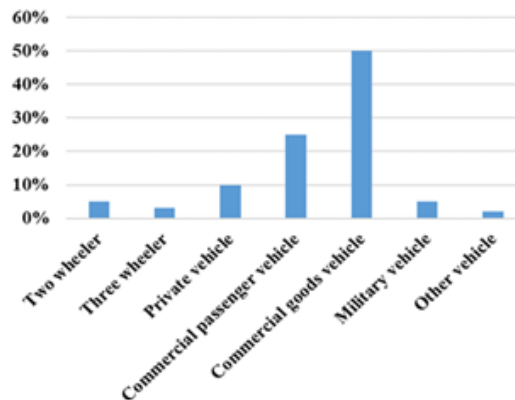| Parts	Percentage
Engine	30%
Gear system and differential	25%
Chassis	25%
Body	10%
Cowl	10%

Fig. 5 - What type of vehicle recycling gives the highest profit margins?

4.3 Technological Perspectives

ELV recycling system in India has been operating with inadequate technologies, resulting in low materials recycling and recovery rates. Figure 7 reveals information about technologies employed in the ELV recycling sector to extract values from ELVs. A significant majority, 65 % of stakeholders, have not been upgraded yet to have a high material recycling rate, still operating with outdated technology, whereas 15 % of stakeholders have adopted sophisticated technology to enhance material extraction. A total of 20 % of stakeholders have partially upgraded their equipment. ELVs contain a significant amount of glass and plastic materials. Recycling glass and plastic is of

paramount importance and needs sophisticated technologies. Table 3 illustrates that a substantial majority of ELV recyclers, 85 % of stakeholders, do not have the technology and equipment to recycle glass and plastic materials. In contrast, an insignificant fraction of ELV recyclers (5 %) have the facility for recycling plastic and glass materials, and they are mostly formal ELV recyclers. Varying ages of ELVs come to ELV recyclers for recycling. Table 4 enumerates the age range of abandoned vehicles that come for recycling. The survey found that 35 % of ELVs' age range is within 12 years, whereas 38 % of ELVs are between 13-18 years old. An insignificant fraction of ELVs (4 %) is over 30 years old.
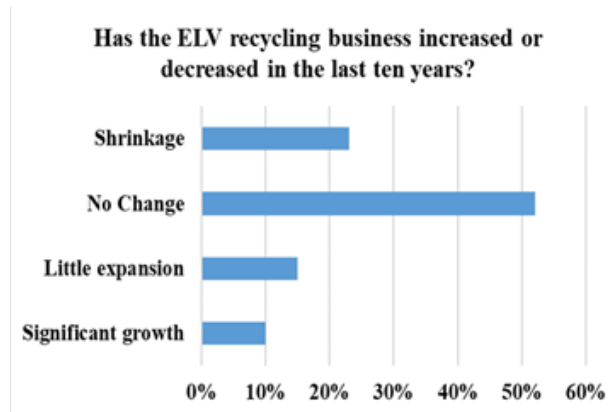

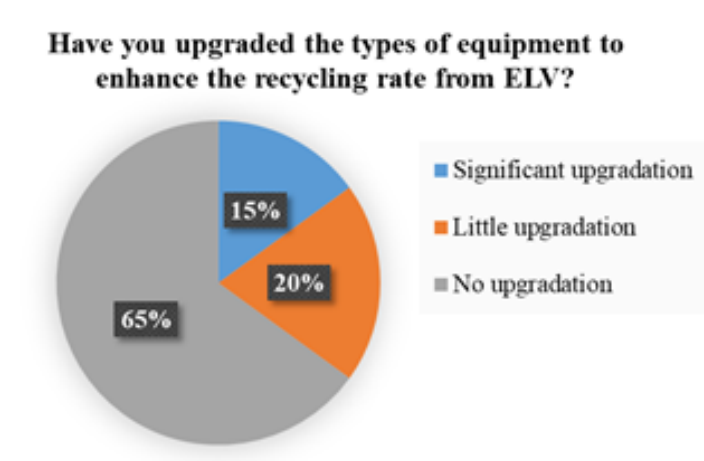**Fig. 6 - Has the ELV recycling business increased or decreased in the last ten years?**

Fig. 7 - Have you upgraded the types of equipment to enhance the recycling rate from ELV?

Table 3 - Do you recycle glass and plastic components?

	Percentage
Both glass and plastic recycling	5%
Glass recycling only	3%
Plastic recycling only	7%
neither plastic nor glass recycling	85%

Table 4 - Age of the vehicles that generally come to the ELV treatment center

Year	Percentage
0-12 Year	35%
13-18 Year	38%
19-24 Year	17%
25-30 Year	6%
Above 30 Year	4%

5. SWOT Analysis

Based on our observations and gathered information and data, a SWOT analysis has been carried out to determine the challenges and opportunities of the ELV recycling system in India. The SWOT analysis enables a thorough assessment of India's ELV recycling system. Strengths and weaknesses are internal, while opportunities and threats are external factors. The challenges are categorized into weaknesses and threats, while the strengths and opportunities reflect opportunities. Table 5 illustrates the SWOT analysis of the ELV recycling system in India.

Table 5 - The SWOT analysis

Strength	Weakness
• One of the biggest vehicle manufacturing hubs in the world. • Sufficient human resources. • A municipal solid waste treatment system has been introduced partially. • Largest emerging economy. • Continuous innovation and strong R&D sustainability.	• Absence of legislative and regulatory framework. • Lack of public awareness. • Material inputs are insufficient. • Lack of practical framework. • Informality in ELV recycling sector.
Opportunity	**Threat**
• Potential market size; India has been undergoing rapid industrialization. • High values recovery. • A significant ELV recycling facility center has been developed.	• Lack of collaboration between ELV recycler and vehicle manufacturer. • No assistance from the government and business-unfriendly policy. • Lack of advanced technology.

6. Recommendations

Based on observations, this study offers certain insightful recommendations to enhance the performance of India's ELV recycling system.

6.1 Awareness and Public Education

Public awareness plays an imperative role in enacting any constructive policy and adopting the new sustainability paradigm. As this study observed, the lack of awareness among the masses is a potential barrier that thwarts sustainable development in ELV recycling. The government of India should promote public awareness through practical means and launch awareness-promoting programs for individuals. From primary schooling, the government should introduce mandatory awareness-related lessons.

6.2 Appropriate Infrastructure

In the realm of ELV recycling in India, a conspicuous dearth of appropriate infrastructure and a robust regulatory framework persists, thus engendering an environment of informality within the ELV recycling sector. As of present, the governing authority has yet to formulate comprehensive guidelines to govern and streamline ELV recycling practices. Consequently, it becomes imperative for the Indian government to promptly embark upon the development of adequate infrastructure and policies to rectify the prevailing inadequacies. By doing so, India can lay the groundwork for achieving a higher material recycling rate and effectively eradicate informality from the ELV recycling landscape. Moreover, such a concerted effort toward bolstering infrastructure will synergistically contribute to the overarching goal of fostering sustainability in the realm of ELV management.

6.3 Sustainable Model

The authority should adopt the sustainable model for the ELV recycling system, as a sustainable model not only enables to have a higher material extraction rate but also mitigate climate change. A sustainable model is one where all stakeholders interact and participate toward a better, greener future for all. The Indian authority should promote the sustainable model to all involved stakeholders.

6.4 Performance Evaluation

In India, there is still no performance evaluation system that can monitor and evaluate the operations of ELV recyclers from a sustainable perspective. The Indian government should construct a management board that will assess the performance of ELV recyclers and monitor the environmental impacts.

6.5 Research and Development

The dearth of research dedicated to ELV recycling is readily apparent within extant literature. Research and development (R&D) serves as a pivotal catalyst for economic growth, engendering a dynamic climate of innovation, invention, and advancement. Thus, it behooves the Indian government to diligently allocate ample resources towards bolstering research and development initiatives, thereby fostering the generation of novel knowledge that will accelerate the trajectory of sustainable development.

7. Conclusions

The present study endeavors to shed light on the existing landscape of ELV recycling in India, where informality prevails as a potential impediment to sustainability. A comprehensive evaluation of India's ELV recycling system is conducted, exploring its technological, socio-economic, and environmental facets. This research has brought to the fore critical factors that will be pivotal in shaping and implementing future regulatory and legal frameworks. Among these factors are the lack of social awareness, insufficient investments, and limited economic incentives within the ELV recycling industry, compounded by inadequate technologies for optimal value recovery from ELVs. Employing a SWOT analysis, the study delves into the challenges and opportunities inherent in India's ELV recycling system, leveraging its status as one of the world's leading vehicle manufacturing hubs and an emerging economic powerhouse as primary strengths, while identifying the dearth of advanced technology and public awareness as principal obstacles. Armed with a comprehensive evaluation of India's ELV recycling system, this paper proffers insightful recommendations aimed at fortifying its performance and expediting the pursuit of sustainability within the ELV recycling sector in India.

Acknowledgement

References

[1] Li, Y.; Liu, Y.; Chen, Y.; Huang, S.; Ju, Y. (2022). Projection of End-of-Life Vehicle Population and Recyclable Metal Resources: Provincial-Level Gaps in China. Sustain Prod Consum 2022, 31, 818–827, doi: 10.1016/J.SPC.2022.03.034.

[2] Molla, A.H.; Shams, H.; Harun, Z.; Ab Rahman, M.N.; Hishamuddin, H. (2022). An Assessment of Drivers and Barriers to Implementation of Circular Economy in the End-of-Life Vehicle Recycling Sector in India. Sustainability, 14, 13084, doi:10.3390/su142013084.

[3] Modoi, O.C.; Mihai, F.C. (2022). E-Waste and End-of-Life Vehicles Management and Circular Economy Initiatives in Romania. Energies 2022, Vol. 15, Page 1120, 15, 1120, doi:10.3390/EN15031120.

[4] Yi, S.; Lee, H. (2021). Economic Analysis to Promote the Resource Circulation of End-of-Life Vehicles in Korea. Waste Management, 120, 659–666, doi: 10.1016/J.WASMAN.2020.10.033.

[5] Harun, Z.; Hossain Molla, A.; Radzi, M.; Mansor, A.; Ismail, R. (2022). Development, Critical Evaluation, and Proposed Framework: End-of-Life Vehicle Recycling in India. Sustainability, Vol. 14, Page 15441 2022, 14, 15441, doi:10.3390/SU142215441.

[6] Jang, Y.C.; Choi, K.; Jeong, J.H.; Kim, H.; Kim, J.G. (2022). Recycling and Material-Flow Analysis of End-of-Life Vehicles towards Resource Circulation in South Korea. Sustainability, Vol. 14, Page 1270 2022, 14, 1270, doi:10.3390/SU14031270.

[7] Yuan, X.; Liu, M.; Yuan, Q.; Fan, X.; Teng, Y.; Fu, J.; Ma, Q.; Wang, Q.; Zuo, J. (2020). Transitioning China to a Circular Economy through Remanufacturing: A Comprehensive Review of the Management Institutions and Policy System. Resour Conserv Recycl, 161, 104920, doi: 10.1016/J.RESCONREC.2020.104920.

[8] Numfor, S.A.; Takahashi, Y.; Matsubae, K. (2022). Energy Recovery from End-of-Life Vehicle Recycling in Cameroon: A System Dynamics Approach. J Clean Prod, 132090, doi: 10.1016/J.JCLEPRO.2022.132090.

[9] Harun, Zambri, Wan Mustafa, Wan Muhammad Syahmi, Abd Wahab, Dzuraidah, Abu Mansor, Mohd Radzi, Saibani, Nizaroyani, Ismail, Rozmi, Mohd. Ali, Hasani, Hashim, Noor Azuan, and Mohd Pisal, Siti Maisarah. (2020). "An Analysis of End-of-Life Vehicle Policy Implementation in Malaysia from the Perspectives of Laws and Public Perception", Jurnal Kejuruteraan 33: (3), 709-718. dx.doi.org/10.17576/jkukm-2021-33(3)-28

[10] Sitinjak, Charli, Ismail, Rozmi, Tahir, Zurinah, Fajar, Rizqon, Simanullang, Wiyanti Fransisca, Bantu, Edward, Samuel, Karuhanga, Che Rose, Rosniza Aznie, Mat Yazid, Muhamad Razuhanafi, Harun, Zambri. (2022).

"Acceptance of ELV Management: The Role of Social Influence, Knowledge, Attitude, Institutional Trust, and Health Issues." Sustainability 14(16): 10201, https://doi.org/10.3390/su141610201.

[11] Molla, A.H.; Shams, H.; Harun, Z.; Kasim, A.N.C.; Nallapaneni, M.K.; Rahman, M.N.A. (2023). Evaluation of End-of-Life Vehicle Recycling System in India in Responding to the Sustainability Paradigm: An Explorative Study. Sci Rep 2023, 13, doi:10.1038/s41598-023-30964-7.

[12] Al-Quradaghi, S.; Zheng, Q.P.; Betancourt-Torcat, A.; Elkamel, A. (2022). Optimization Model for Sustainable End-of-Life Vehicle Processing and Recycling. Sustainability, Vol. 14, Page 3551 2022, 14, 3551, doi:10.3390/SU14063551.

[13] Petronijević, V.; Đorđević, A.; Stefanović, M.; Arsovski, S.; Krivokapić, Z.; Mišić, M. (2020). Energy Recovery through End-of-Life Vehicles Recycling in Developing Countries. Sustainability, Vol. 12, Page 8764 2020, 12, 8764, doi:10.3390/SU12218764.

[14] Li, J.; Yu, K.; Gao, P. (2014). Recycling and Pollution Control of the End of Life Vehicles in China. J Mater Cycles Waste Manag, 16, 31–38, doi:10.1007/S10163-013-0226-6.

[15] Harun, Z.; Molla, A.H.; Khan, A.; Safuan, U.Z.; Azman, M.S.S. bin; Hashim, H. (2022) End-of-Life Vehicle (ELV) Emission Evaluation Using IoT in Malaysia. In Proceedings of the 2022 9th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE); IEEE, 2022.

[16] Molla, A.H.; Moghtaderi, S.H.; Harun, Z.; Jedi, A.; Nallapaneni, &; Kumar, M.; Hossain Molla, A.; Manoj Kumar, N. (2023). Insights into End-of-Life Vehicle Recycling and Its Quality Assessment Systems in Malaysia Reveals the Need for a New Stakeholder-Centric Approach for Vehicle Waste Management. http://mc.manuscriptcentral.com/tpmr, 11, doi:10.1080/21693277.2023.2236676.

[17] Bulson, E.E.; Remucal, C.K.; Hicks, A.L. (2023). End-of-Life Circulation of PFAS in Metal Recycling Streams: A Sustainability-Focused Review. Resour Conserv Recycl, 194, 106978, doi: 10.1016/J.RESCONREC.2023.106978.

[18] Sakai, S. ichi; Yoshida, H.; Hiratsuka, J.; Vandecasteele, C.; Kohlmeyer, R.; Rotter, V.S.; Passarini, F.; Santini, A.; Peeler, M.; Li, J.; et al. (2014). An International Comparative Study of End-of-Life Vehicle (ELV) Recycling Systems. J Mater Cycles Waste Manag, 16, 1–20, doi:10.1007/S10163-013-0173-2.

[19] Zhao, Q.; Chen, M. (2011). A Comparison of ELV Recycling System in China and Japan and China's Strategies. Resour Conserv Recycl, 57, 15–21, doi: 10.1016/J.RESCONREC.2011.09.010.

[20] Wang, J.; Sun, L.; Fujii, M.; Li, Y.; Huang, Y.; Murakami, S.; Daigo, I.; Pan, W.; Li, Z. (2021). Institutional, Technology, and Policies of End-of-Life Vehicle Recycling Industry and Its Indication on the Circular Economy-Comparative Analysis Between China and Japan. Frontiers in Sustainability, 0, 13, doi:10.3389/FRSUS.2021.645843.

[21] Soo, V.K.; Doolan, M.; Compston, P.; Duflou, J.R.; Peeters, J.; Umeda, Y. (2021). The Influence of End-of-Life Regulation on Vehicle Material Circularity: A Comparison of Europe, Japan, Australia and the US. Resour Conserv Recycl, 168, 105294, doi: 10.1016/J.RESCONREC.2020.105294.

[22] Arora, N.; Bakshi, S.K.; Bhattacharjya, S. (2018). Framework for Sustainable Management of End-of-Life Vehicles Management in India. Journal of Material Cycles and Waste Management 21:1 2018, 21, 79–97, doi:10.1007/S10163-018-0771-0.

[23] Sharma, L.; Pandey, S. (2020). Recovery of Resources from End-of-Life Passenger Cars in the Informal Sector in India. Sustain Prod Consum, 24, 1–11, doi: 10.1016/J.SPC.2020.06.005.

[24] Ghosh, S.K.; Ghosh, S.K.; Baidya, R. (2021). Circular Economy in India: Reduce, Reuse, and Recycle Through Policy Framework. Circular Economy: Recent Trends in Global Perspective, 183–217, doi:10.1007/978-981-16-0913-8_6.